
UNITED STATES MARINE CORPS
THE BASIC SCHOOL
MARINE CORPS TRAINING COMMAND
CAMP BARRETT, VIRGINIA 22134-5019

**DAY OPTICS AND
OBSERVATION THEORY
B2E2667
STUDENT HANDOUT**

Day Optics and Observation Theory

Introduction

The Marine Corps uses optical enhancing devices on a daily basis. As individual Marines we use them to observe the environment that we operate in so we can see and assess the objects and people in that environment. As a leader on the battlefield we use day optics to build situational awareness and aid us in developing a situation. Our enhanced view and better understanding of the environment or possibly the threat allow us to make better tactical decisions when the time comes.

Importance

In order for the Marine Corps to effectively fight enemies with ever changing ways to disguise their action, intent and themselves, we need to understand the capabilities, limitations, and proper use of the optics devices in our inventory. If our devices are not employed properly it will lead to ineffective use on the battlefield. As leaders of Marines we will need to ensure our Marines know how to properly and effectively utilize day optic devices on the battlefield.

In This Lesson

We will discuss the Rifle Combat Optic (RCO) and Binoculars, two systems that you will find in an infantry rifle company. We will also discuss some practical techniques and uses on the battlefield.

This lesson covers the following topics:

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Learning Objectives

Terminal Learning Objectives

Given an area to observe in daylight and in limited visibility, perform un-aided observation to identify objects and sounds. (0300-CMBH-1202)

Terminal Learning Objectives (Continued)

Given observation aiding equipment, and an area to observe during daylight and limited visibility, perform aided observation to identify objects and/or sounds. (0300-CMBH-1203)

Enabling Learning Objectives

Without the aid of references, describe the observation process without omission. (0300-CMBH-1202a)

Without the aid of references, describe the elements of visual perception without omission (0300-CMBH-1202b)

Without the aid of references and considering unaided observation during daylight or limited visibility, describe how to search field of view without omission. (0300-CMBH-1202c)

Without the aid of references, describe techniques that enhance hearing without omission. (0300-CMBH-1202e)

Without the aid of references and considering use during daylight and limited visibility, describe how to employ magnifying optics without omission. (0300-CMBH-1203a)

Rifle Combat Optic (RCO)

The RCO (also known as the ACOG) is a day and night dual source illuminated telescopic sight with a tritium illuminated reticle pattern designed for the M-16 family of weapons. The RCO system uses fiber optics to provide a low light and night aiming capability and eliminates the need for batteries. The RCO incorporates Tritium Lamp lights in order to illuminate the reticle pattern present in the optic. It is calibrated to accommodate for bullet drop when a round is fired which eliminates the need for adjustments once the system is zeroed with the weapon. It is a four power optic. The USMC fielded the RCO in order to give its Marines the ability identify and accurately engage targets out to 800 meters.



- Rifle mounted aiming system
- USMC Nomenclature:
 - AN/PVQ-31A – used with the M-16 (20" Barrel)
 - AN/PVQ-31B – used with the M-4 (14" Barrel)

Rifle Combat Optic (continued)



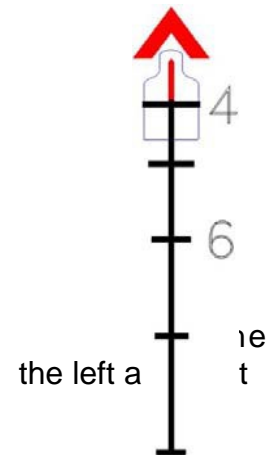
Specifications of the RCO

- Length
 - 5.8 inches
- Weight
 - 15.3 ounces
- Magnification
 - 4 times
- Objective Aperture
 - 32mm
- Eye Relief (Distance from the eye to the eye piece)
 - 1.5 inches for optimal picture
- Exit Pupil (Size in diameter of the eyepiece you look through)
 - 8mm wide
 - Allows for rapid target acquisition
 - Allows for considerable eye latitude
- Field of View
 - 7.0 degrees at 100m (12.7m across)
- Chevron Width
 - 19 inches at 300m
 - 19 inches is the average width across a person's chest.

Rifle Combat Optic (continued)

Range Estimation

- RCO provides accurate range estimation out to 800m.
 - The reticle pattern in the RCO gives us a range estimation capability.
 - The picture on the right shows a target at 400m and what it would look like in the RCO if aiming center mass on the target.
 - A target that is as wide as the chevron from left to right would be 300m away.
 - Aim point for a target that is 300m away tip of the vertical line between side of the chevron.
 - Targets that show larger than the width of the chevron are closer than 300m.



Bindon Aiming Concept (BAC)

- The BAC is able to combine the traditional long-standoff marksmanship capability with the ultimate in close combat transitional aiming. BAC utilizes both eyes to acquire, track, identify and aim in on a target. The eye that is not sighted in on the target has a full field of view so that you can acquire, and track moving targets. Once the RCO is positioned on the target the brain automatically starts to use the information from that eye that is getting the magnified image, thus allowing you to identify and aim in on the target.

Benefits of using the RCO

- Allows individual to quickly estimate range of targets.
- Acquire partially camouflaged targets at ranges beyond 300 meters.
- Allows individual to see into and through shadows, windows and foliage.
- Acquire targets in low light conditions.
- ID enemy vs. non-combatant vs. friendly.
- Reduce potential for fratricide.
- Enhance combat exchange ratio in our favor.
- Allows for accurate fire support.
- Reduce ammo expenditure.

Battle Sight Zero (BZO) for the RCO

- RCO can be zeroed using two methods.
 - 100m BZO (preferred method)
 - Uses the top tip of the chevron to aim in on the target.
 - Fire three rounds.
 - Find the center of the grouping.
 - Adjust the center of the grouping both vertically and horizontally. Three clicks will move the impact of the round one inch at 100m.
 - 33m BZO (36 yard)
 - Use the 300m aim point.
 - Fire three rounds.
 - Find the center of the grouping
 - Adjust the center of the grouping both vertically and horizontally. Nine clicks will move the impact of the round one inch at 33m.
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Squad Day Optic (SDO)

The Squad Day Optic is a 3.5 power, day/night, dual source illuminated telescopic sight with a tritium illuminated reticule pattern designed for the M249 Squad Automatic Weapon (SAW) with either the long or short barrel. The SDO uses fiber optics to provide a low light and night aiming capability and eliminates the need for batteries. Similar to the RCO, the SDO incorporates Tritium Lamp lights in order to illuminate the reticule pattern present in the optic. The reticule pattern is also similar to the RCO, in that it is calibrated to accommodate for bullet drop when a round is fired. This eliminates the need for adjustments once the sight is zeroed to the weapon. The SDO also incorporates a ruggedized miniature reflex sight (RMR) bolted to the top of the SDO body. The RMR provides no magnification, but is designed to engage targets at close ranges when speed is critical. The USMC is fielding the SDO in order to give M249 gunners the ability identify and accurately engage targets at greater distances.



Specifications of the SDO

- Length
 - 8.7 inches
 - Weight
 - 1.34 pounds
 - Magnification
 - 3.5 times
 - Objective Aperture
 - 35mm
 - Eye Relief (Distance from the eye to the eye piece)
 - 2.4 inches for optimal picture
 - Virtual Aperture
 - 10mm wide
 - Allows for rapid target acquisition
 - Allows for low light use
 - Field of View
 - 5.5 degrees at 100m (31.5 feet across)
 - Reticule
 - Horseshoe Dot with BDC
-

Specifications of the RMR

- Length
 - 45mm
 - Weight
 - 1.2 ounces
 - Magnification
 - 1 time
 - Sight Window
 - 22mm x 16mm
 - Reticule
 - Horseshoe Dot with BDC
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Binoculars (Leupold Binoculars)

Binoculars are a day optic that allows the individual Marine the ability to acquire, identify and track targets and objects on the battle field. Approximately 90% of the information that a normal human being uses comes from their sense of sight. The use of binoculars can enhance the detail and situational awareness of units and unit leaders.

Nomenclature of Binoculars

- Diopter lens (eyepiece lens)
 - This lens and lens adjustment is used to focus the image from the binoculars on to the retina.
- Body
 - Section of the binoculars that houses the internal workings and lenses of the binoculars.
- Objective lens
 - This is the light collecting portion of the binoculars and it is the most important part of providing the picture that you are trying to see.



Binoculars (Leupold Binoculars) (continued)

Specifications of the Leupold Cascade Binoculars

- Length
 - 5.5 inches
- Weight
 - 22.9 ounces
- Magnification
 - 8 times
- Objective Aperture
 - 42 mm
- Angular Field of View
 - 6.5 degrees
- Field of View
 - 11.4 m @ 100m
- Eye Relief
 - 18 mm for optimal picture
- Exit Pupil
 - 5 mm wide
 - Allows for rapid target acquisition
 - Allows for considerable eye latitude

Techniques for Holding Binoculars to Your Eyes. Using these techniques will aid in the quality of picture that you will get when using your binoculars.

- Hold binoculars lightly to you eyes in order to not transmit any of your body movement through your binoculars.
- Rest the binoculars on the heels of your hands.
- Wrap your thumbs and fingers around the objective lenses in order to block out any unwanted light.

Binocular Holding Positions. There are two basic positions for holding binoculars, the unsupported method and the supported method.

- Unsupported Method - allow your elbows to rest naturally along your body with just enough tension to keep the binoculars steady and to your eyes as you look through them.
- Supported Method - resting your elbows or arms on a sturdy tree limb, a vehicle, the prone position, or using a stable sitting position and allowing the binoculars to remain steady as you look through them.

Binoculars (Leupold Binoculars) (continued)

Adjusting and Focusing Binoculars. Using binoculars is very simple, but you need to know how to adjust them to your individual eyes and eyesight. You do this by setting an interpupillary distance, adjusting the diopter adjustment, focusing the binoculars and using the proper eye relief. Once adjusted, binoculars can become an invaluable tool for you in the field.

Setting Interpupillary Distance

- Hold the binoculars up to your eyes.
- Look through the binoculars with both eyes.
- Move the two lenses (body) closer or farther away from each other until you see one circular image. The two optical tubes will move upon a hinge in the middle of the body of the binoculars.

Setting the Diopter Adjustment

(Center Diopter)

- Pull up the lockable diopter adjustment dial on the top of the center focus dial.
- View an object about 100 yards away.
- Cover the left objective lens with your hand.
- Adjust the center focus wheel (located in between the two optical tubes) until the image presented to your right eye is clear and sharp.
- Cover the right objective lens with your hand.
- Adjust the diopter adjustment dial until the image presented to your left eye is clear and sharp.
- Push down the lockable diopter adjustment dial so that it locks in place.
- Your binoculars are now set for your eyes.

Setting Focus

- Look at object.
- Rotate center focus wheel until picture is clear and sharp.

Virtual Aperture/Exit Pupil

This value relates to the size of the pupil in your eye. Your pupil is usually 3-5 mm during normal day light viewing. It is 6-8 mm wide during periods of low light visibility. The value of the exit pupil or the virtual aperture will determine whether the optic is good during periods of low light visibility or just during the day. In order to figure out what the value of the exit pupil is for an optic you simply divide the diameter of the objective lens by the magnification. The resulting number is the exit pupil for the optic you evaluating. $\text{RCO } 32\text{mm} / 4\text{x Mag} = 8\text{mm exit pupil}$. Thus this optic is as advertised a good optic for periods of low light observation

Observation Theory and Techniques

Observation is a three part process. You must see, assess and then communicate. You can not be successful as a unit in the conduct of your mission if you are not using this three step process of observation.

According to studies about 90% of the information that your brain uses in order to orient and make decisions comes from your sense of vision. This makes it extremely important to assess what you see and to put it in context and sometimes take it out of context in order to see what is actually there or see what is missing or out of place.

Observation is a two way street. If you can see the enemy then the enemy can see you. There are ways to camouflage yourself when attempting to observe others as well as ways to avoid being observed by others. Being familiar with these methods of camouflage is important in order to use them to your advantage and to understand how the enemy will try to hide themselves from you.

The communication process depends greatly upon the circumstances of your immediate situation. It may be appropriate to simply report information to higher headquarters via radio and continue your current operation; for less time-critical information, you may be able to delay communication until the debrief of your operation. Other situations may dictate an immediate response. Should you come into contact with an enemy unit and they are unaware of your presence, you most likely will have time to communicate an ADDRAC report to orient the rest of your unit and prepare for an assault. If in that same scenario the enemy appears aware of your unit's presence, your communication process may consist of firing the first round followed by additional instructions, as able.

Context and Scanning. Our eyes give us a majority of the information that our brain processes in order to gain situational awareness and build a picture of your surroundings. Our brain, however is a very powerful tool and has a tendency to fill in the blanks or make some things look like they belong when they actually do not because of the context that the objects are in. For instance for Americans, all the years of reading from left to right allow human brain to fill in things that may not actually be there when scanning a scene in that direction because of the context that they are in. Context is a powerful tool which enables us to make quick decisions. However, observation at times requires you to take a detailed look at areas, objects and/or people in order to assess a possible threat or course of action. It is important to see what is actually there and not what the enemy wants you to see or what your brain is causing you to believe is there. Scanning an area in the opposite direction (right to left) than your brain is used to seeing things is one way to allow you to break out the details necessary to accurately assess the environment.

Using Binoculars to Aid in Observation. Binoculars are a great tool to aid in observation. They allow you to get a magnified view of an object or area that is off in the distance. In that magnified view you are able to make out greater detail. Items or details that your unaided eye would not be able to pick up are now presented with enough clarity to actually assess what you are seeing. Communicating the details that you see to others within the unit will complete the three step process of See, Assess

and Communicate. It will also increase the situational awareness for unit leaders and members of your unit to accomplish the mission.

Binocular Techniques. The following are techniques that can be used in order to aid the individual Marine or unit leaders in recognizing and assessing threats in the environment that they are operating in.

Burning through Vegetation

A bush or piece of vegetation that blocks your vision of things behind it to the un-aided eye can be seen with the help of binoculars. Place the binoculars to your eyes and focus the binoculars past the branches that are in front of you. Objects on the other side of the bush or vegetation can be seen clearly while you remain hidden and camouflaged.

Cresting the Top of Hills

Using the just mentioned technique of burning through vegetation can allow you to remain on the military crest of the hill that you are on and observe the other side. Walk up the hill until your head is just above the crest of the hill. You will have enough standoff from the vegetation on the hill top that you will not be noticed. Place your binoculars to your eyes and focus through the vegetation in front of you in order to bring objects on the other side of the hill into view while remaining hidden and camouflaged.

Looking through Holes

When you come up to a wall or surface that has small holes in it you can use your binoculars to see what is on the other side without exposing yourself to danger. Hold one of the oculars up to the hole in the wall or surface. Look into that ocular with one of your eyes. Objects on the other side can be seen and focused on.

Looking into Shadows

A shadow can be used to mask figures and objects. Using binoculars can help you see those figures and objects that you would not otherwise see if you looking with the un-aided eye. Because of their ability to magnify a picture and collect light, binoculars give the user the ability to see into the shadows. Place the binoculars to your eyes and look at the shadow or into a shaded area. Fill the field of view of the binoculars with the shadowed area. This allows your pupils to adjust to the light level that is in the field of view and allows you to focus on the figures or objects present in that shadow.

Nine Elements of Visual Perception

Line, Edge and Outline

The boundary or border, a spatial location, a separation or distinction.

Everything, especially man-made items, have a line or edge to them. These lines and edges often lead to the outline of an object. The human eye picks up lines, edges and outlines very easily. An untrained individual may see a line or edge while a trained individual will see outline.

Any object silhouetted against a contrasting background is conspicuous. Any smooth, flat background, such as water, a field, or best of all, the sky, will cause an object to become well delineated. However, special care must be taken when searching areas with an uneven background, as it is more difficult to detect the silhouette of an object

Shape

A shape is the visual characteristic surface configuration of a thing. It is distinguished from its surroundings by its outline, contour, or figure.

Outlines are created when lines and edges come together. When we perceive the outline, it becomes a shape.

The human eye readily picks up shapes, especially of other humans or potential threats (e.g. rifle). Some objects can be recognized instantly by their shape, particularly if it contrasts with the background. Experience teaches people to associate an object with its shape or outline. At a distance, the outline of objects can be seen well before the details can be determined. The human body and the equipment that a Marine carries are easily identified unless the outline has been altered. Marines can alter this outline by applying camouflaging techniques.

Contrast or Value

Contrast is a difference, especially a strong dissimilarity, between entities or objects compared. Value is the relative importance or tone of something, darkness or lightness of color.

Color

The aspect of things that is caused by differing qualities of the light reflected or emitted by them, definable in terms of the observer or of the light as:

The appearance of objects or light sources described in terms of the individual's perception of them, involving hue, lightness, and saturation for light sources.

The characteristics of light by which the individual is made aware of objects or light sources through the receptors of the eye, described in terms of dominant wavelength, luminance, and purity.

Colors have a value to them as well as a baseline. The greater the contrasting color, the more visible the object becomes. This point is especially true when the color is not natural for that area. The best camouflage colors are those that are most difficult to determine exact color. Color alone will usually not identify the object but is often an aid in locating it.

Texture	<p>The distinctive physical composition or structure of something, especially with respect to the size, shape, and arrangements of its parts, appearance and feel of a surface.</p> <p>Similar to color, texture has a baseline. An object with a smooth surface reflects light and becomes more obvious than an object with a rough surface that casts shadows on itself. An extremely smooth object becomes shiny. If an object has a surface that contrasts with its surroundings, it becomes conspicuous.</p>
Rhythm and Flow	The patterned, recurring alternations of contrasting elements, movement or variation characterized by the regular recurrence or alternation of different quantities or conditions; a pattern created by lines, forms and colors.
Movement	<p>Movement is one of the biggest disturbances to a baseline. The human eye is strongly attracted to any movement. The human eye can detect another human or animal within seconds by watching the movement of an appendage.</p> <p>a. Physical movement is from the person actually moving. This is readily detectable.</p> <p>b. Visual movement is from a person disturbing vegetation or an object, thus causing the vegetation or object to move. This could also be a lack of movement which creates an anomaly in the baseline.</p>
Light (reflecting, sunlight and shadow)	Light impacts colors and the value of colors. Some animals have a dark back and light underbelly. The sun lightens the dark back color and the shadow cast from above darkens the lighter underbelly near the ground making the animal seem less three-dimensional.

	<p>Flat surfaces reflect light while rough surfaces absorb it. The reflections from a belt buckle, watch, or optical device can be seen over a mile away from the source. Any shine will attract the observer's attention.</p> <p>In sunlight, an object or a man will cast a shadow that can give away his presence. Shadows may be more revealing than the object itself. Care must be taken to detect alterations of the natural shape of a shadow. Where light is excessively bright, shadows will look especially black. Contrast will be extreme, and in this exaggerated contrast the observer's eye cannot adjust to both areas simultaneously. This requires the observer to "isolate" the shadowed area from the bright sunlight so that his eye can adapt to the shadow.</p>
Positive and Negative Space	<p><u>Positive Space.</u> Positive space is a space that takes up mass (solid objects) such as buildings, trees, signs, vehicles, etc. Typically, a Marine cannot see through positive space. The human eye will naturally move from positive space to positive space, as the eye is attracted to this. Example: Tree lines, your eyes are attracted to trunks and prominent branches.</p> <p><u>Negative Space.</u> Negative space is the space between the positive spaces. This is the area of shadow and background activity that an untrained observer often overlooks. Good camouflage resembles negative space; it doesn't resemble positive space, such as a leaf. When observing, a Combat Hunter must observe the negative space as well. The Marine, like the enemy, wants to operate in the negative spaces when possible.</p>

Using hearing to aid the observation process. Although the majority of information your brain will process does come through visual cues, your sense of hearing can also play a major role in the observation process. Aural cues may allow you to initially orient your eyes on a potential target or they may be used to refine a target, assisting in the update of the enemy's composition, current activity, or direction of movement. A key factor in successfully incorporating this form of intelligence collection is to remain silent and still for prolonged periods of time. This can be put into practice by conducting long and short halts along a patrol or establishing a listening post/observation post (LP/OP) to support your defensive scheme of maneuver.

Summary

The enemy that we are fighting will do everything that they can to camouflage their activities and intent. Knowing and understanding how to exploit the weaknesses in the enemy's attempt to deceive is the key to early detection. The RCO, SDO and binoculars coupled with some basic observation techniques will allow you and your Marines to gain an advantage on the battlefield.

References

Reference Number or Author	Reference Title
MCWL 3-35.3X	Combat Hunter
MCIP 3-11.01	Combat Hunter Operations (Draft)
MCWP 3-11.3	Scouting and Patrolling
MCIP 3-15.01	M16A4 Rifleman's Suite
TM 11064-12&P	Rifle Combat Optic
Leupold Binoculars	Reference Manual

Glossary of Terms and Acronyms

Term or Acronym	Definition or Identification
ACOG	Advanced Combat Optical Gunsight
BZO	Battle Sight Zero. Sets a weapon systems aimpoint for a specific distance. M-16s have a BZO of 300m.
Diopter	Is the adjustable eyepiece lens that focuses an image onto the retina for the clearest picture.
Exit Pupil	Also known as Virtual Aperture, it is a measurement of the amount of light that will pass through the optical system. To find the size of the Exit pupil divide the size of the Objective Aperture by the magnification of the optic.
Eye Relief	Distance between your eye(s) and the eyepiece of the optic.
Objective Aperture	The light collecting lens of an optic. Measured in millimeters across the diameter of the lens.
RCO	Rifle Combat Optic
RMR	Ruggedized Miniature Reflex Sight (part of the SDO)
SDO	Squad Day Optic

Notes
